⑫ **EUROPEAN PATENT APPLICATION**

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㊷ **Color valve multiplexer.**

㊄ A coating material dispensing device control system comprising multiple coating material type control valves (74), each valve (74) having a coating material input port, a coating material output port and a control port for controlling the passage of the type of coating material controlled by that particular coating material type control valve (74) from its input port to its output port, means (62, 64) for generating control signals for controlling the multiple coating material type control valves (74), means (66) for multiplexing the control signals, means (70) for demultiplexing the multiplexed control signals, means for coupling the means (62, 64) for generating the control signals to the multiplexing means (66), means (58, 52, 60) for coupling the multiplexing means (66) to the demultiplexing means (70), and means (72) for coupling the demultiplexing means (70) to the multiple coating material type control valves (74).
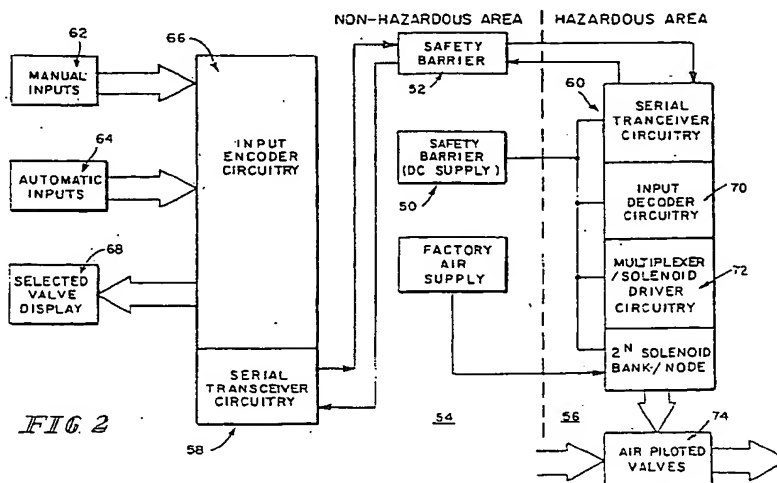
FIG. 2

96 housing. Whatever the source(s) of these control inputs, multiplexer 96 encodes them in the established format and drives fiber optic transceiver 86 accordingly. The optical signals cross from area 80 into area 82 where they are received by a fiber optic transceiver assembly 88 associated with the slave equipment (color controlling valves V_1, V_2, . . . V_{2N}) 106 there. The fiber optic transceiver assembly 88 associated with equipment 106 converts the received optical signal to safe electrical signals and supplies them to a demultiplexer associated with equipment 106. On receipt by the demultiplexer, these signals are demultiplexed to the signals which control valves V_1, V_2, . . . V_{2N} and ultimately control what colors are dispensed by the dispenser(s) in area 82 and in what sequence.

Additional control of the dispenser(s) in area 82 illustratively is provided through the discrete safety barrier(s) 90 from control input source(s) 92. These additional control signals may include, for example, dispensing device trigger position, which controls flow of whatever fluid is chosen, be it a color, solvent, low pressure air, high pressure air, or the like, through the dispensing device. They may also include solvent valve control signals, low and high pressure air control signals, and the like.

Another embodiment of the invention is illustrated in schematic and block form in Figs. 4-7. In the following detailed description of the embodiment of Figs. 4-7, specific circuit components and terminal numbers and names and pin numbers are provided for purposes of completeness. These terminal and pin identifiers are the specific terminal and pin identifiers for the identified circuit components. This does not constitute a representation, nor should such a representation be inferred, that there are no other circuit components available from the same or other manufacturers which will perform the described functions, or that the terminal and pin identifiers of such other circuit components will be the same as those given for the specifically identified circuit components.

Referring to Fig. 4, color valve information in BCD or binary form is provided from an industrial controller (not shown) such as, for example, an Allen-Bradley model 5/60 programmable logic controller, to a plug J1.

The eight bits 0-7 are provided on lines B-4 --B-7 and A-4 -- A-7, respectively, of plug J1. Unused higher bits are coupled to +5VDC through respective 1K resistors of a resistor matrix 120 through respective jumpers 122 to the unused bits. This prevents unused bits from floating low and spuriously signalling the controller. The bits are coupled through respective 1N5308 current regulating diodes 124-1 to 124-8 to the anodes of LED's in respective Hewlett-Packard HCPL-2231 optical

isolators 126-1 to 126-4. Each integrated circuit 126-1 to 126-4 provides two isolators and thus is capable of providing isolation for two of the input bits on B-4 -- B-7 through A-4 -- A-7.

Diodes 124-1 through 124-8 provide 2.5 mA output current for any forward bias from 7VDC through 100VDC and so condition the input signals at terminals B-4 -- B-7 through A-4 -- A-7. The cathodes of the LED's in integrated circuits 126-1 to 126-4 are coupled to the PLC ground terminal, A-1, B-1 of plug J1. A jumper strip 130 is provided in the event that the signals at terminals B-4 -- B-7 through A-4 -- A7 are sufficiently conditioned that such isolation is unnecessary. Otherwise, the jumpers are connected to the output terminals of Schottky AND gates in the optical isolator integrated circuits 126-1 through 126-4. The output terminals, pins 7 and 6, of optical isolator integrated circuits 126-1 through 126-4 are coupled to input terminals A8 -- A1, respectively, of a National Semiconductor 74HCT245 bus transceiver/latch 132. The output terminals B8 -- B1, respectively, of bus transceiver/latch 132 are coupled to lines P0.0 -- P0.7, respectively, of a system bus 134.

Information can also be provided to the system bus 134 from manual pushbuttons through a plug J3. Manual bits M0 -- M7 are coupled to terminals A1 -- A8 of a National Semiconductor 74HCT245 bus transceiver/latch 140. The output terminals B1 -- B8, respectively, of bus transceiver/latch 140 are coupled to lines P0.0 -- P0.7, respectively, of the system bus 134. The input terminals A1 -- A8 and output terminals B-1 -- B-8 of bus transceiver/latch 140 are coupled to #5VDC through respective 10K pull-up resistors of 10K resistor matrices 142, 144.

Additional inputs and outputs are provided to and from the circuit illustrated in Fig. 4 for an RS-422 interface at plug J1 terminals B-10 -- B-13 (RS-422 OUT-, RS-422 IN+, RS-422 IN-/ FUNCTION SELECT 1, and RS-422 OUT+, respectively). These are coupled to the RI-, DO+, DO-, and RI+ terminals, respectively, of a National Semiconductor DS8921A integrated circuit differential-to-serial/serial-to-differential converter 148. Terminals DI and RO of integrated circuit 148 are coupled to terminals P3.0 and P3.1, respectively, of an Intel D87C51FA integrated circuit microcontroller 150. The RS 422 IN-/FUNCTION SELECT 1 terminal is also coupled to terminal P3.7 of microcontroller 150. A FAULT terminal of plug J1 is coupled to terminal P1.3 of microcontroller 150. An ENABLE (LOCAL) terminal of a plug J5 is coupled to an input terminal, pin 2, of a dual AND-OR invert gate 152 which serves as a signal decoder. Gate 152 illustratively is a National Semiconductor 74HC51 integrated circuit.

The ENABLE (LOCAL) terminal is also coupled to ground through a 10K pull-down resistor. A lo-

cal/remote (L/R) SWITCH (CENTER) terminal is coupled through a 74HC04 inverter to input pin 4 of gate 152. The L/R SWITCH (CENTER) terminal is also coupled to input pin 3 of gate 152. An ENABLE (REMOTE) terminal of plug J1 is coupled through a 1N5308 current regulating diode 124-9 to the anode of an LED in a Hewlett Packard HCPL-2231 optical isolator 126-5. A FUNCTION SELECT 0 terminal of plug J1 is coupled through a 1N5308 diode 124-10 to the anode of the other LED in optical isolator 126-5. The cathodes of the LED's in optical isolator 126-5 are coupled to the PLC ground A-1, B-1 of plug J1. The ENABLE (REMOTE) and FUNCTION SELECT 0 terminals of plug J1 are also coupled to jumper strip 130. If the signals at these terminals are in appropriate condition, they can be jumpered directly into the remaining circuitry of Fig. 4. Otherwise, the jumpers are connected to the output terminals of the Schottky AND gates in optical isolator 126-5. Either way, the signal on the FUNCTION SELECT 0 terminal is supplied to terminal P1.2 of microcontroller 150. The signal on the ENABLE (REMOTE) terminal is supplied through a 74HC04 inverter to an input terminal, pin 5, of gate 152.

The ENABLE (CLEAR) terminal of plug J5 of the system is coupled to input terminal P3.5 of microcontroller 150 and through a 10K pull-down resistor to ground. Input terminal P3.6 of microcontroller 150 is coupled to ground if the information on plug J1, terminals B-4 — B-7 and A-4 -- A-7 is binary. If that information is BCD, terminal P3.6 of microcontroller 150 is coupled to +5VDC through a resistor of a 10K resistor matrix 158. Additional 10K resistors of the matrix 158 couple #5VDC to terminals P1.2, P1.3, P3.0 -- P3.4, and P3. 7. Clock signals for microcontroller 150 are provided by a 12MHz crystal coupled across terminals X1-X2 of microcontroller 150. 30pF capacitors are coupled between terminals X1 and X2 and ground. Terminals P0.0 -- P0.7 of microcontroller 150 are coupled to terminals P0.0 --P0.7, respectively, of the system bus 134. Terminals P1.4 -- P1.7 of microcontroller 150 are coupled through respective pull-up resistors of a 10K resistor matrix to #5VDC and to jumper terminals on a jumper strip 162. The opposite jumper terminals of jumper strip 162 are coupled to ground. Placement of jumpers across selected strip 162 terminals establishes the RS-422 address of the system illustrated in Figs. 4-7.

The P2.1 - P2.5 terminals of microcontroller 150 are coupled to the bus 134 DIR (direction) terminal of bus transceiver/latch integrated circuit 132 and to the TDS, RDE, RDA and MR terminals, respectively, of a Standard Microsystems COM90C84P parallel-to-serial/serial-to-parallel transceiver 164 (Fig. 5). The BCLK terminal of transceiver 164 is coupled to terminal X2 of microcon-

troller 150. The DA terminal of transceiver 164 is coupled through a 74HC04 inverter to terminal P3.3 of microcontroller 150. Terminal TC of transceiver 164 is coupled to the CN terminal of a 74HC74 D flip-flop 166, the Q terminal of which is coupled to the SCLK terminal of transceiver 164. Terminals D0 - D7 of transceiver 164 are coupled to lines P0.0 - P0.7, respectively, of the system bus 134. Serial color valve control information in Manchester code is provided on output terminal TD of transceiver 164. Serial color valve status information in Manchester code appears as input data at input terminal RD of transceiver 164.

The L/R SWITCH (CENTER) of the system is coupled to terminal P3.4 of microcontroller 150 and through a 74HC04 inverter to an input terminal of a 74HC32 OR gate 170, the output terminal of which is coupled to terminal G̅ of bus transceiver/latch 140 (Fig. 4). Terminal P3.4 of microcontroller 150 is also coupled to an input terminal of a 74HC32 OR gate 172, the output terminal of which is coupled to terminal G̅ of bus transceiver/latch 132. An additional input terminal of each of OR gates 170, 172 is coupled to terminal P2.0 of microcontroller 150.

Two Motorola MC14495 BCD-to-seven segment display decoder drivers 174, 176 (Fig. 5) have their A, B, C and D input terminals coupled to bus 134 lines P0.0 - P0.7, respectively. The LE input terminals of both of integrated circuits 174, 176 are coupled to terminal P1.0 of microcontroller 150. The a, b, c, d, e, f and g terminals of integrated circuits 174, 176 are coupled to terminals 14, 15, 16, 4, 3, 2, 1, 8, 9, 10, 11, 7, 6 and 5, respectively, of a Hewlett Packard HDSP-7503, two digit, seven segment display (not shown) which displays current system status, for example, which one of a number of different color valves is presently actuated. The display blanking terminals 12, 13 of the dual seven segment display are coupled to the drain terminal of a VN0808L field effect transistor, the source of which is coupled to ground and the gate of which is coupled to terminal P1.1 of microcontroller 150.

The outbound data from terminal TD of transceiver 164 is coupled to an input terminal, pin 1, of a National Semiconductor 75451 peripheral driver 178. Pin 2 of peripheral driver 178 is coupled through a 10K resistor to +5VDC, and pin 3 of peripheral driver 178 is coupled through a 180Ω resistor to +5VDC and directly to input terminals, pins 2,6 and 7, of a Hewlett Packard HFBR-1412 fiber optic link transmitter 180. Pin 4 of peripheral driver 178 and pin 3 of transmitter 180 are coupled to ground. A 30pF capacitor is coupled across pins 3 and 4 of peripheral driver 178. The light output from transmitter 180 is coupled to one end of a 62.5/125μm fiber optic cable 182 which extends from the non-hazardous area 184 into the haz-

ardous area 186.

A complementary 62.5/125μm fiber optic cable 188 conveys system status information back from the hazardous area 186 to the non-hazardous area 184 where that information is coupled to a Hewlett Packard HFBR-2412 fiber optic link receiver 190. The output terminal, pin 6, of receiver 190 is coupled to terminal RD of transceiver 164. Pin 2 of receiver 190 is coupled to #5VDC, to ground through a .1μF capacitor, and to pin 6 through a 120Ω resistor. Pins 3 and 7 of receiver 190 are coupled to ground.

Fiber optic cables 182, 188 terminate in the hazardous area 186 at a Hewlett Packard HFBR-2412 fiber optic link receiver 192 and a Hewlett Packard HFBR-1412 fiber optic link transmitter 194, respectively. The output terminal, pin 6, of receiver 192 is coupled through a 74HCT04 inverter to the RD terminal of a Standard Microsystems COM90C84P parallel-to-serial/ serial-to-parallel transceiver 196. Pin 2 of receiver 192 is coupled to +5VPC, to ground through a .1μF capacitor and to pin 6 of receiver 192 through a 120Ω resistor. Pins 3 and 7 of receiver 192 are coupled to ground. The TP terminal of transceiver 196 is coupled to an input terminal, pin 2, of a National Semiconductor 75451 peripheral driver 198. Pin 1 of peripheral driver 198 is coupled through a 10K resistor to +5VDC. Pin 3 of peripheral driver 198 is coupled through a 180Ω resistor to +5VDC, directly to pins 2, 6 and 7 of transmitter 194, and to ground through a 30pF capacitor. Pin 4 of peripheral driver 198 is coupled to ground, as is pin 3 of transmitter 194.

Terminals D0 - D7 of transceiver 196 are coupled to the P0.0 - P0.7 lines, respectively, of a hazardous area bus 200. These lines of the bus 200 are coupled through respective 10K resistors of a 10K resistor matrix 202 to +5VDC. These lines are also coupled to the P0.0 - P0.7 terminals, respectively, of an Intel D87C51FA microcontroller 204. The $\overline{\text{TDS}}$, $\overline{\text{RDE}}$, $\overline{\text{RDA}}$ and $\overline{\text{MR}}$ terminals of transceiver 196 are coupled through the bus 200 to terminals P2.2 - P2.5 of microcontroller 204. A 12MHZ crystal is coupled across terminals X1, X2 of microcontroller 204 and each of terminals X1, X2 is coupled to ground through a 30pF capacitor. Terminal X2 of microcontroller 204 is coupled to the BCLX terminal of transceiver 196.

The TC terminal of transceiver 196 is coupled to the CX terminal of a 74LS74 D flip flop, the Q terminal of which is coupled to the SCLK terminal of transceiver 196. The DA terminal of transceiver 196 is coupled through a 74HCT04 inverter to the P3.2 terminal of microcontroller 204. The P1.0 - P1.7 output terminals of microcontroller 204 are coupled to the B1 - B8 terminals, respectively, of a National Semiconductor 74HC245 octal latch 210

which latches the color valve selection information from the microcontroller 204. The decoded color valve bits for valves numbered 0-7 appear on terminals A1-A3 of octal latch 210.

An additional three bits of information, on output terminals A5-A7 of octal latch 210, are coupled to the input terminals A, B and C, respectively, of a National Semiconductor 74HC137 three-to-eight decoder 212. The inverted information on output terminals Y1 - Y4 of decoder 212 is the address of one of four cards, each of which controls eight color valves. Thus, only one card at a time will be energized and it will only be possible then to energize one of the eight color valves controlled by that card. Only two intrinsic barriers per system of Figs. 4 - 7 will thus be required, one to power the one card of the four which is addressed on one of terminals Y1 - Y4 of three-to-eight decoder 212, and the other to power the one color valve on that addressed card addressed by the signals on terminals A1 - A3 of octal latch 210. Selection of the card and the color valve on that card is ENABLED by a signal coupled through bus 200 from terminal P2.1 of microcontroller 204. Octal latch 210 is enabled by a signal coupled to its terminal $\overline{\text{G}}$ from terminal P2.0 of microcontroller 204.

Each of the four cards controlled by microcontroller 204 contains the circuitry illustrated in Fig. 7. The input terminals A, B and C of a National Semiconductor 74HC237 three-to-eight decoder 216 on each of the four cards are coupled to the A1 - A3 output terminals of octal latch 210. The LE input terminals of all four three-to-eight decoders 216, inverted, are coupled to the P2.1 output terminal of microcontroller 204. The CS2 input terminal of each of the four three-to-eight decoders 216, inverted, is coupled to a respective one of the inverted Y1 - Y4 output terminals of three-to-eight decoder 212.

The Y0 - Y7 output terminals of each three-to-eight decoder 216 are coupled through respective 390Ω resistors to the anodes of respective LED's in respective Motorola MOC8021 optical couplers 220-1 -- 220-32, only eight, 220-1 -- 220-8, of which are illustrated in Fig. 7. The cathodes of the LED's in optical couplers 220-1 - - 220-32 are all coupled to ground. The output terminal, pin 5 of each optical coupler 220-1 -- 220-32 is coupled to the intrinsic safety barrier output voltage source. The output terminal, pin 4, of each optical coupler 220-1 -- 220-32 is coupled to one terminal of the actuating solenoid (not shown) of a respective one of the thirty-two valves on a color manifold. The other terminals of all of the solenoids are coupled to ground. A flyback diode 222-1 -- 222-32, only eight, 222-1 -- 222-8, of which are illustrated, is coupled across the terminals of each solenoid to damp the flyback pulse which results when that

solenoid is deenergized.

The invention dramatically reduces system cost by passing encoded or multiplexed information to the booth, rather than using discrete control for every color valve. It will be appreciated that the present system reduces the number of PLC output modules and eliminates bundles of pneumatic lines, conductors, and the like. In doing so, it reduces system layout and installation time. It reduces system space requirements by reducing the number of color valve control modules. It also employs a self-diagnostic valve controller.

The system of the invention manipulates manual (switch) or automatic (PLC) information and drives electropneumatic solenoids within a hazardous area for color valve selection.

The system receives valve selection information from manual and automatic inputs and encodes this information for transmission into the hazardous area through a serial data link, thus reducing the number of safety barrier devices devoted to information transmission purposes. Within the hazardous area, the information is decoded and the corresponding valve is energized through a multiplexing circuit and a MOSFET. The multiplexing circuitry permits only one valve to be energized at a time.

A significant distinction between this system and existing devices is the multiplexing of data for color valve selection. In certain embodiments, a serial data link is employed between the non-hazardous and hazardous areas for multiplexed data transmission.

Since only one valve is required to be energized at a time, only a single safety barrier is required for solenoid valve actuation. A serial data link may require an additional safety barrier for non-fiber optic transmission media.

The system of the present invention offers the advantage of reducing the number of control inputs and safety barriers required for a given number of outputs. Response time is greatly enhanced due to the close physical proximity of the electropneumatic solenoids to the air piloted valves.

Claims

1. A coating material dispensing device control system comprising multiple coating material type control valves, each valve having a coating material input port, a coating material output port and a control port for controlling the passage of the type of coating material controlled by that particular coating material type control valve from its input port to its output port, means for generating control signals for controlling the multiple coating material type control valves, means for multiplexing the control signals, means for demultiplexing the multiplexed control signals, means for coupling the means for generating the control signals to the multiplexing means, means for coupling the multiplexing means to the demultiplexing means, and means for coupling the demultiplexing means to the multiple coating material type control valves.

2. The apparatus of claim 1 and further comprising a hazardous area and a non-hazardous area, the demultiplexing means and coating material type control valves being intrinsically safe and
provided in the hazardous area, the means for generating control signals and the multiplexing means being provided in the non-hazardous area.

3. The apparatus of claim 2 wherein the means for coupling the multiplexing means to the demultiplexing means comprises a serial data link.

4. The apparatus of claim 3 wherein the serial data link comprises a fiber optic cable.

5. The apparatus of claim 4 wherein the fiber optic cable is a duplex fiber optic cable.

6. The apparatus of claim 2 wherein the means for coupling the multiplexing means to the demultiplexing means comprises a parallel data link.

7. The apparatus of claim 6 wherein the parallel data link comprises multiple channels, each channel including an optical isolator.

8. The apparatus of claim 6 wherein the means for coupling the demultiplexing means to the coating material type control valves comprises drivers, means for coupling each output of the demultiplexer to an input of a respective one of the drivers and means for coupling an output of each respective driver to a respective one of the coating material type control valves.

9. The apparatus of claim 8 wherein the means for coupling an output of each respective driver to a respective one of the coating material type control valves comprises an electrical to pneumatic solenoid valve.

10. The apparatus of claim 1, 2, 3, 4, 5, 6, 7, 8 or 9 and further comprising a power supply for providing power for the multiplexer and demultiplexer, and means for coupling the power

supply to the multiplexer and demultiplexer.

11. The apparatus of claim 10 wherein the means for coupling the power supply to the demultiplexer comprises a current barrier.
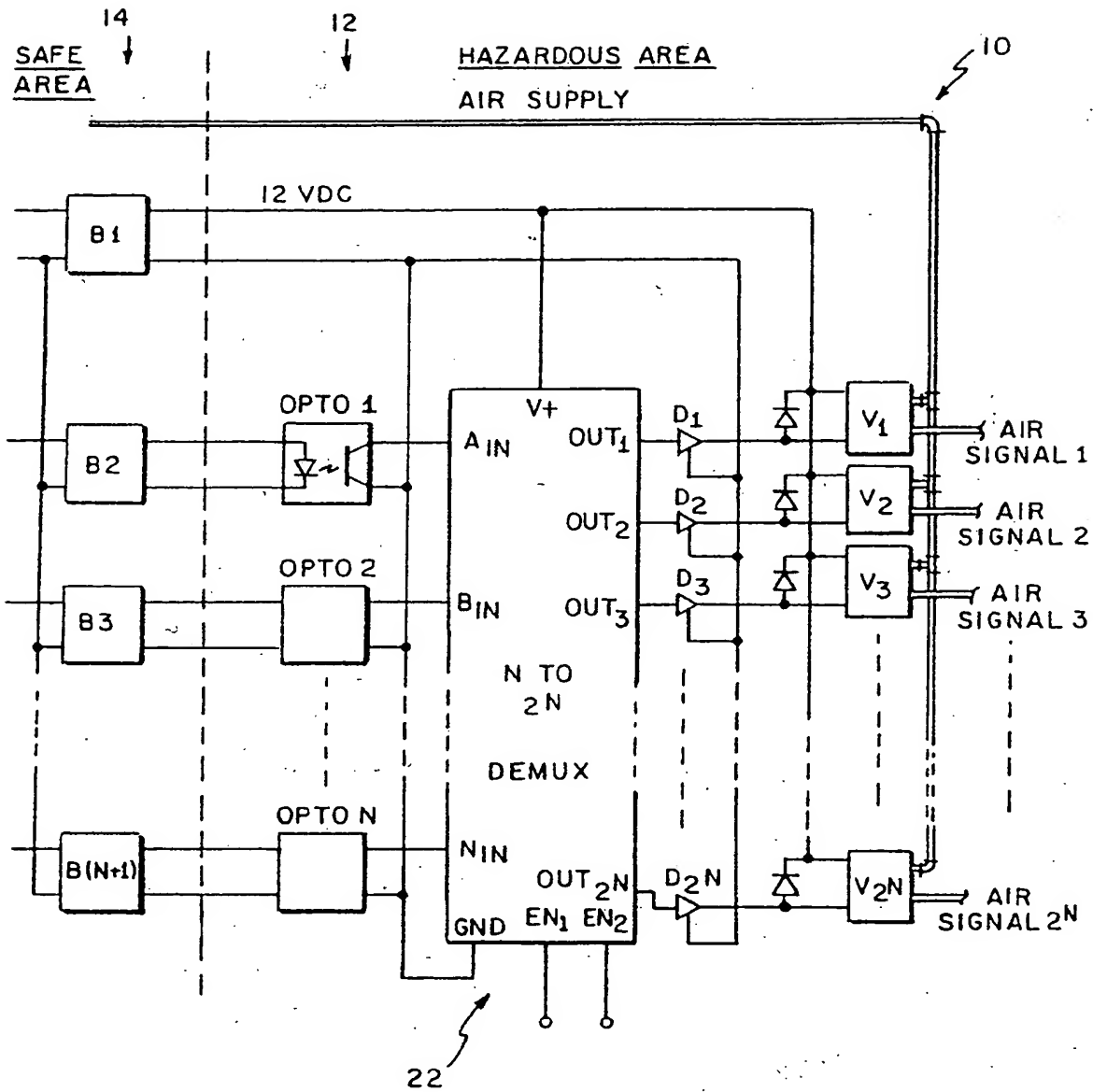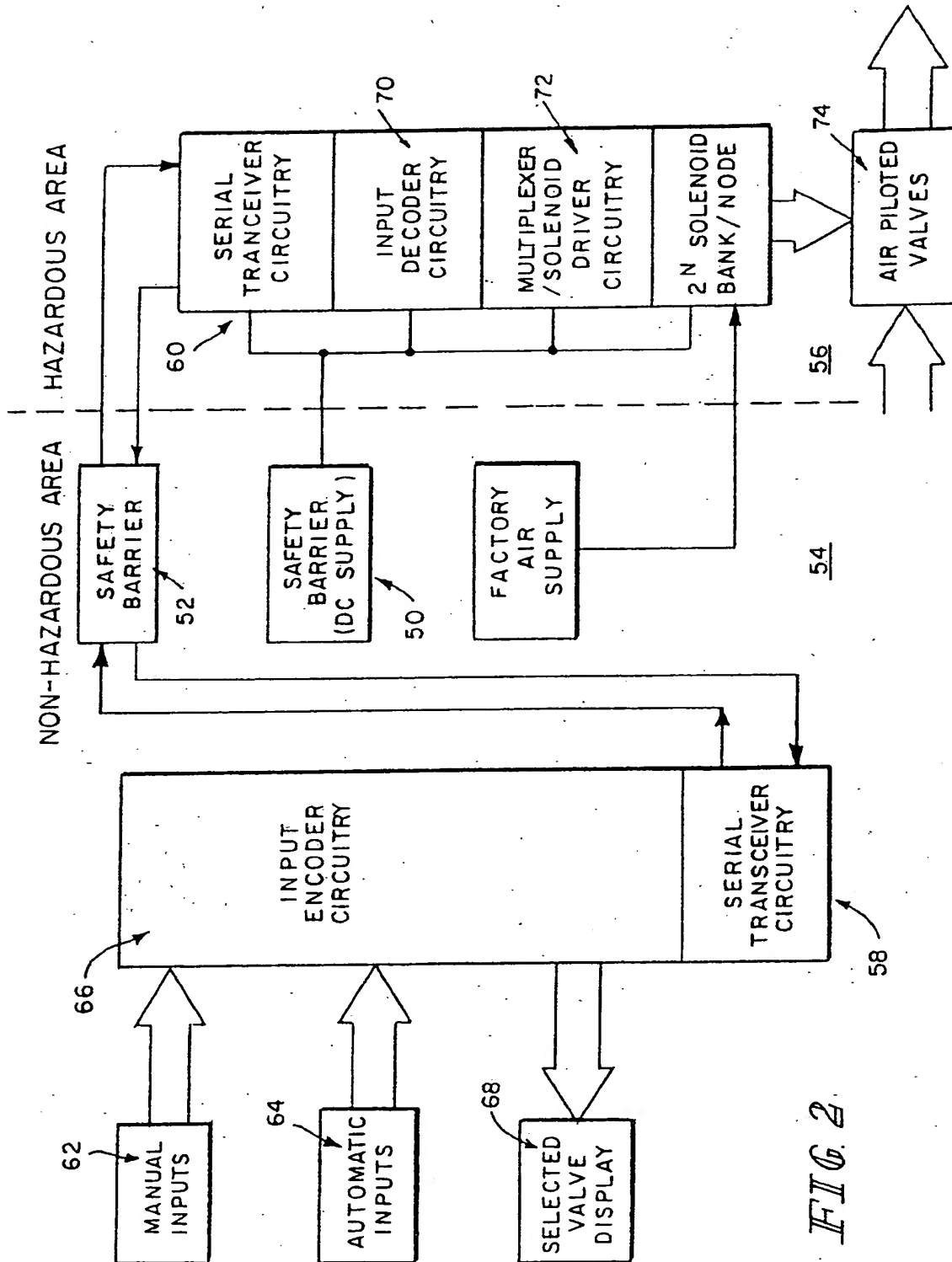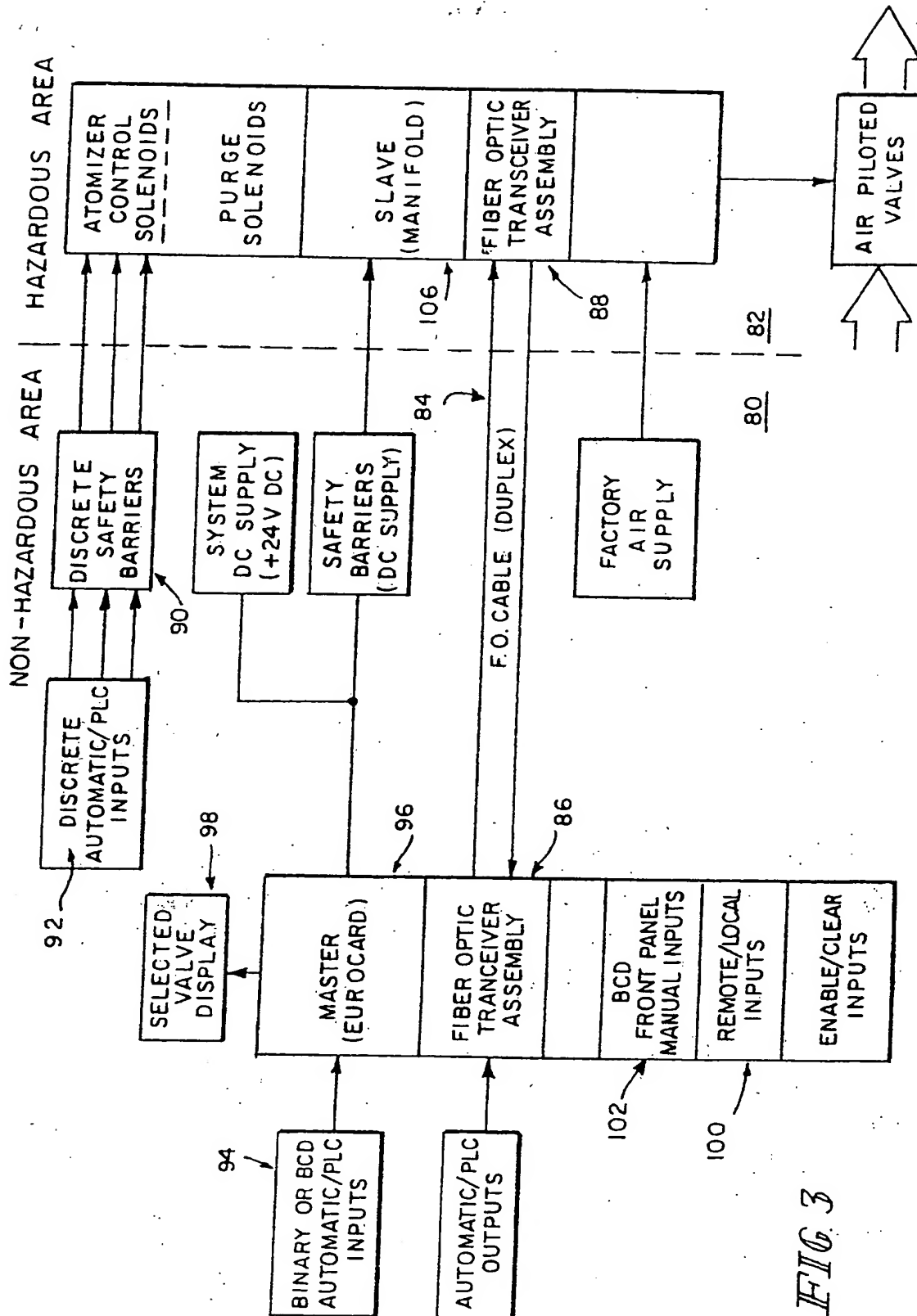
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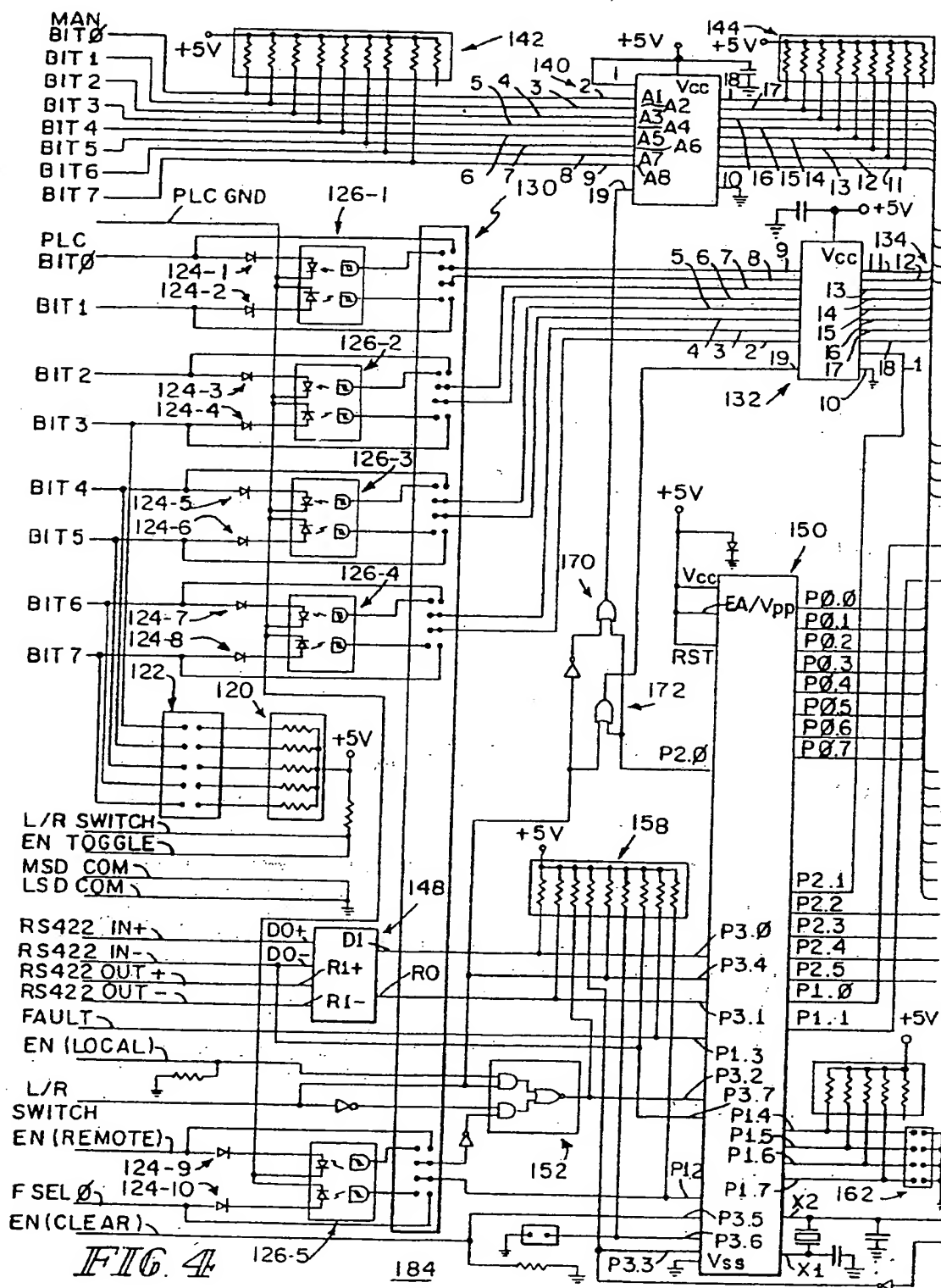
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FIG. 1
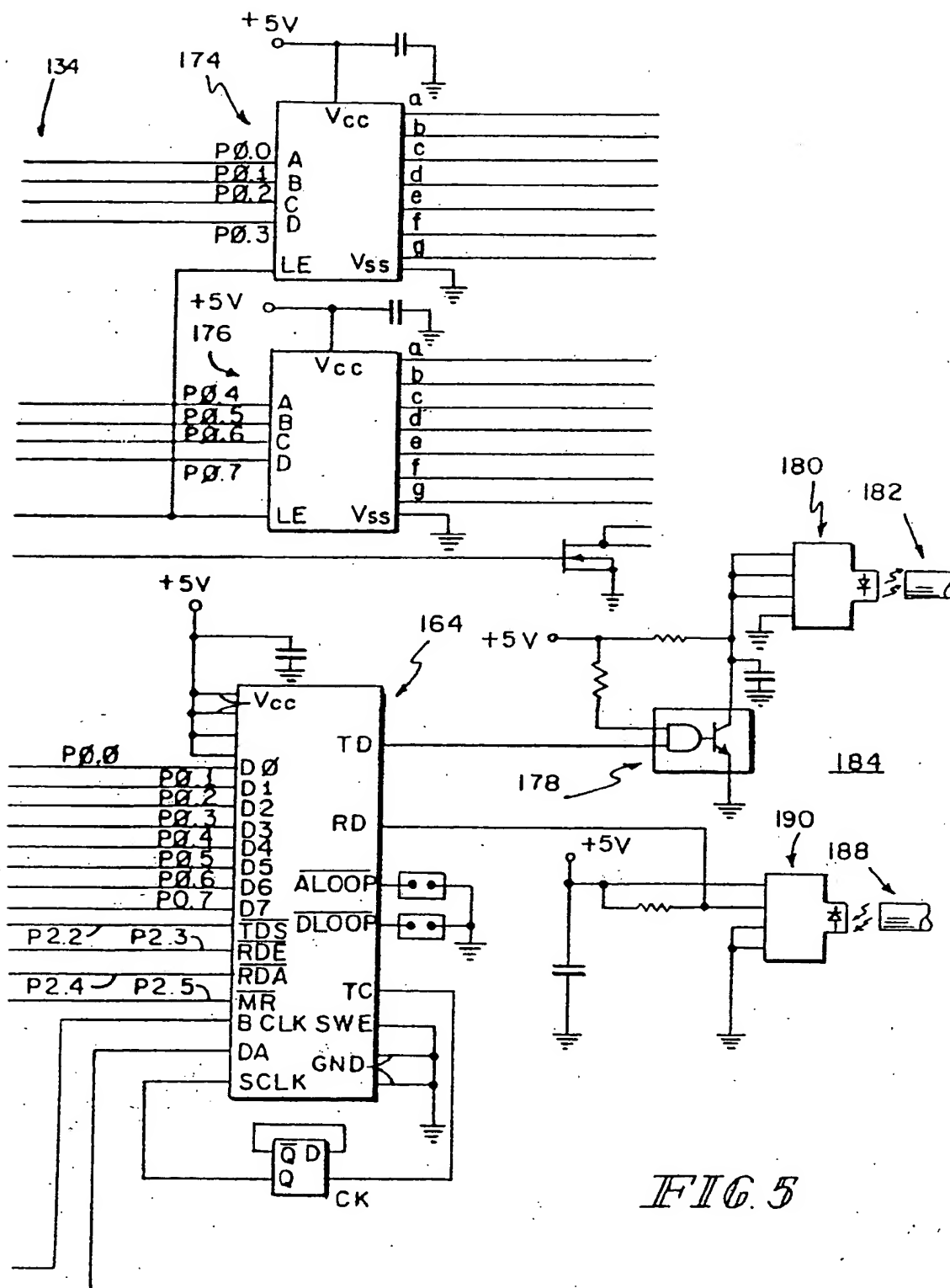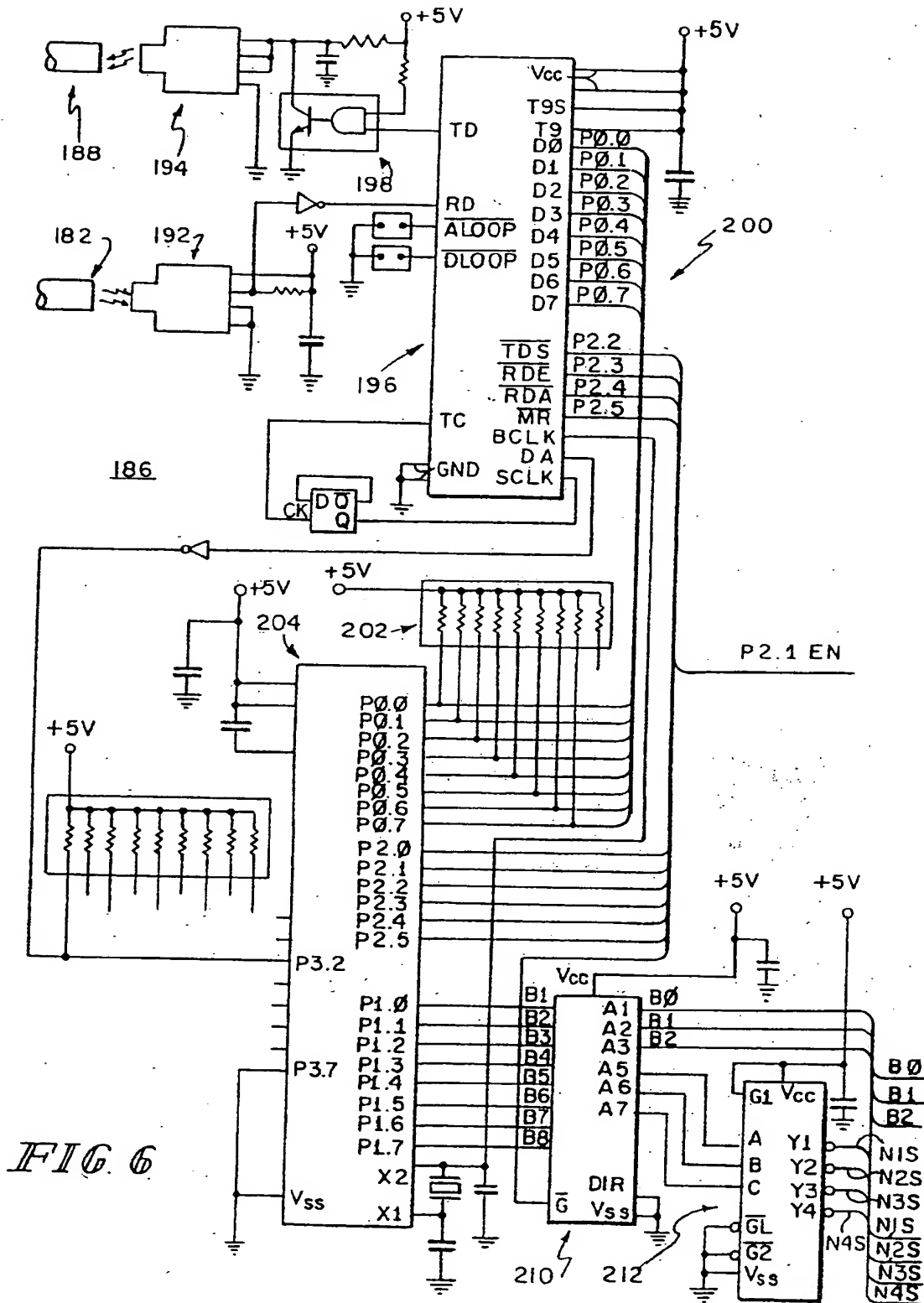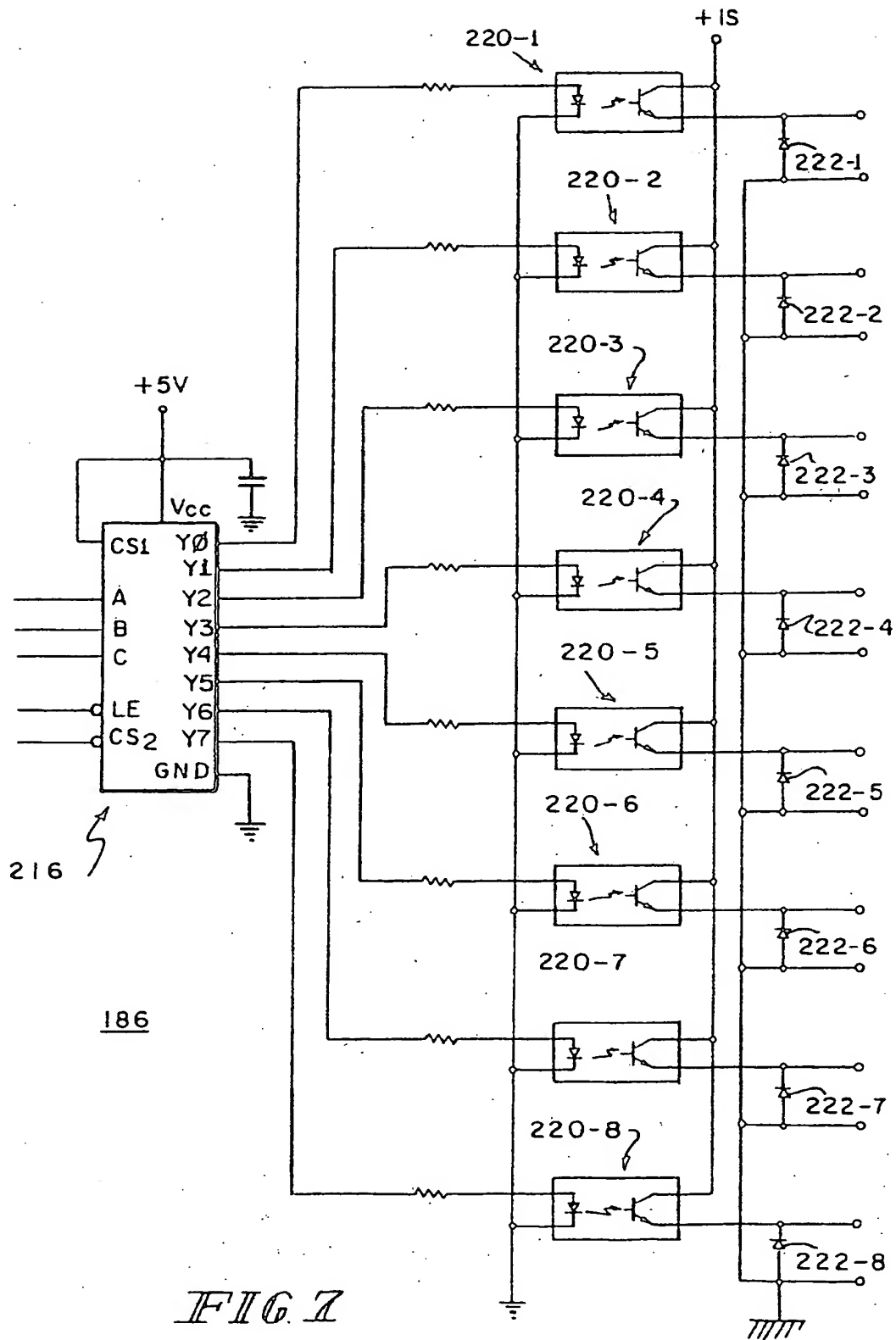
NON-HAZARDOUS AREA | HAZARDOUS AREA

SERIAL TRANCEIVER CIRCUITRY — 70

INPUT DECODER CIRCUITRY

MULTIPLEXER /SOLENOID DRIVER CIRCUITRY — 72

2^N SOLENOID BANK/NODE

60

56

SAFETY BARRIER — 52

SAFETY BARRIER (DC SUPPLY) — 50

FACTORY AIR SUPPLY

54

AIR PILOTED VALVES — 74

INPUT ENCODER CIRCUITRY

SERIAL TRANSCEIVER CIRCUITRY — 58

66

MANUAL INPUTS — 62

AUTOMATIC INPUTS — 64

SELECTED VALVE DISPLAY — 68

FIG 2

FIG 3

FIG. 4

FIG.5

FIG. 6

FIG. 7

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
D,A	US-A-4 957 060 (CANN) * the whole document * ---	1,9	B05B12/14 G05B19/05
A	EP-A-0 387 978 (BEHR INDUSTRIAL EQUIPMENT INC.) * the whole document * ---	1,9	
A	EP-A-0 493 884 (BRITISH GAS PLC) * the whole document * ---	1-4	
A	US-A-4 712 173 (FUJIWARA ET AL.) * the whole document * ---	1	
A	GB-A-1 418 710 (PYE LIMITED) * the whole document * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5) B05B G05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 February 1994	Juguet, J

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